DIY KIT 109 STEPPER MOTOR DRIVER

Stepper motors can be used in a wide variety of hobby applications: searchlights on small boats & cars, video camera positioning, radio antenna control, controls operating through waterproof housing, telescope control where the azimuth, elevation & focus must be varied independently, moving table positioning. In these applications what is required is one or both of a continuous stepping at varying speeds and a single stepping, fine control to get the final position.

This kit is a stepper motor driver for 5, 6 & 8 lead **unipolar** stepper motors. These are the most common types today on the surplus market. The older four lead **bipolar** stepper motors are not supported by this kit. Visual indication that a pulse has gone to the stepper motor is provided by 4 LED's, one connected to each of the four coils in the motor. (This may be very useful if you cannot see the motor and want to be sure that it has stepped.) The direction of stepping can be changed by a switch. Three stepping modes are possible.

The kit uses an IC especially designed to drive 6 lead unipolar stepper motors, the UCN5804B. As will be shown the 5 and 8 lead steppers can be configured into a 6 lead pattern. Download the data sheet for this IC from the Allegro website given below. The various features of this IC are brought out to 5 SPDT switches on the PCB. This kit was designed using Protel for DOS.

ASSEMBLY

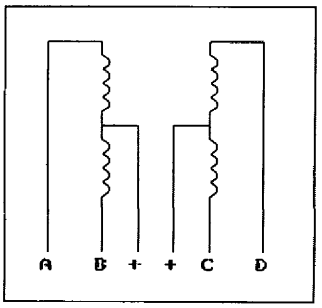
Check the components against the Component listing. Make sure you identify C1, the 474 monoblok. It looks just the same as C2 C4 & C6 which are 104 monobloks with the same pitch. Note there are four links to go on the board. One of the links goes under an IC socket. Make sure the flat on the four LED's corresponds to the bar shown on the overlay. They all face right. It is generally best to solder the lowest height components into the board first. We have included a 6-pin header to make the connection of the stepper motor to the PCB easier.

Motor Identification.

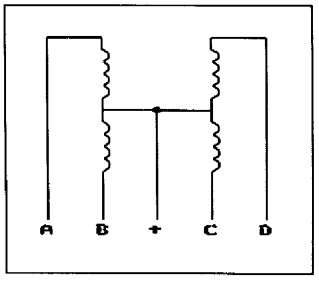
This is straight forward because the number of wires coming out of the motor identifies it. **Bipolar motors** have 4 leads coming out of them. One winding is on each stator pole. These motors are not supported by this kit. They were common in the late 1980's and many kits using discrete components were built to support them.

Unipolar motors may have 5 leads but generally have 6 or 8 wires. In all the motors we have seen, the wires for the 6 & 8 types come out in two bundles of 3 or 4 wires resp. Unipole steppers have two coils per stator pole. In the 8 lead motors the 2 leads from the 2 coils from both stators emerge from the motor. In the 6 lead motors the two coils on each stator pole are joined (opposite sense) together before they emerge from the motor. In the 5 lead motors each of the two joined wires are themselves joined before they leave the motor.

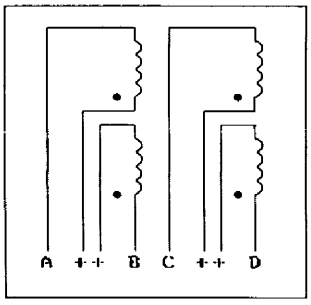
In the **6 wire version** a multimeter (set it to 200ohm resistance range) will show which is the centre lead within each group of 3 leads. Typically the resistance between the centre lead to the other two will be about 40 ohms while the resistance between the outer two leads will be twice that. Call the outer two leads in each of the two bunches of wires A & B, C & D. Solder them into those positions on the PCB. The centre lead in each bunch is the power lead & goes into the pad marked +. Note that it **does not matter** which way around the A/B, C/D leads go onto the pads.



5 wire version. Note that both + pads on the PCB are connected together. In the 5 wire motor these centre leads are connected internally. So to power a 5 lead stepper just connect the common centre tap lead from both phases to one of the + pads. The A/B, C/D leads are connected just as in the 6 lead motors.



8 wire version. In each bunch of 4 leads find the 2 pairs of wires connected to each phase of the motor. Take one of each and join them together. This is now the common lead to connect to the + pad just as in the 6 lead case. The remaining leads are A & B and C & D to the PCB..



Now there are 1, possibly 2, complications. First the common connection must join the coils in the opposite sense. This refers to the way in which they are wound. This means that the dot on one coil is joined to the no-dot end on the other coil in the diagram. There is no way to tell the sense of the coils unless you have the motor winding colour specification which for surplus motors is generally missing. So you just have to try it. Now if the wires are colour coded the same in both bundles this is just a matter of two possibilities to try. If the wires are not colour coded then there are four possibilities. You will not damage the motor during this testing if connections are wrong. The motor will either not work or oscillate to and fro when the power is connected.

CIRCUIT DESCRIPTION

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We have designed the kit so that the stepper motor can be run continuously at a fast or low stepping rate then,

PARTS LIST - K109

Resistors 1/4W, 5%:		
180R brown grey brown...	R1	1
1K brown black red	R2 R3	2
1M brown black green.....	R4	1
1M potentiometer.....	POT	1
1000uF/35V electrolytic capacitor	C3	1
0.47uF 474 monoblok capacitor	C1	1
0.1uF 104 monoblok capacitor	C2 C4 C5 C6	4
UCN5804B	IC2	1
LM/NE555 nmos	IC1	1
7805 voltage regulator	IC3	1
2 pole terminal block.....		1
8 pin IC socket.....		1
16 pin IC socket.....		1
SPDT PCB-mounted switch.....		5
6 pin header.....		1
3mm red LED		4
4 leg tact switch.....		1
K109 PCB.....		1

when it nears the desired position, it can be switched to single step mode and manually pulsed into final position. Another switch controls the direction. A third switch can turn the IC off and any power to the motor is removed. Two other switches bring out halfstep and one phase control modes supported by the IC. A 555 IC is configured to deliver a continuous stream of pulses to pin 11 of the 5804. The frequency is determined by the values of the potentiometer and C1. Alternatively, the single step switch allows individual pulses to be delivered manually to the 5804 using a tact switch. A switch debounce circuit is present using R4 & C5. LED's are included on the output of the 5804 to show which phases of the motor are powered.

The Driver. The 5804 stepper driver is one of those marvellous devices that replaces a handful of discrete components. The driver will operate motors at up to 35V and 1.25A. The step input is to pin 11 and direction goes to pin 14. Pins 9 and 10 control one phase and half step operation, respectively. Ref. 6 shows how to drive the IC direct from a computer.

Motor Movement.
To make the motor step, power is applied to each coil in turn. The 4 windings have to be energised in the right sequence. Steppers have three different stepping methods: wave, two phase & half-step. This is because there are three basic patterns of energising the coils to make them move. The last two are the most efficient. These patterns are given in the data sheet on the 5804. No more than 2 coils are on at any one time.

In **wave drive** (or one phase operation) only one coil is on at any time. In **two phase drive** two coils are always on. In **halfstep drive** the number of coils energised cycles between 1 & 2. We will not go into the details here since they are given every year or so in the hobby electronics magazines and in text books. Two of the best write-ups starting from basics are references 2, 4 and 5 below. You can see the pattern of coils being turned on/off by looking at the LED's as the motor steps.

As the motor is spinning, try varying the supply voltage. This will make the motor run more roughly or smoothly. Stepping motors are very sensitive to supply voltage variations.

If you want the RUN stepping rate to be slower then replace the 1M potentiometer by a 5M or even 10M pot.

What to do if it does not work
If there are more than 2 LED's on then there is a short circuit on the output of the 5804. Check that all the 4 links are added to the board. Check the 555 IC is in the correct way.

Ballast or Forcing Resistor
For two reasons a low value (typically 20 to 60 ohm), 5W or 10W cement resistor is sometimes included in both the + lines between the 5804 and the stepper motor.

Lenz's Law. Voltage driving gets into a time constant problem (L/R) which limits speed & power. If R is increased then the time constant is reduced. However, for hobby applications it does not matter if the time constant is 50msec or 10 msec.

Current Limiting. The resistor helps to limit current to the motor. This is to help reduce overheating when it is stopped (not stepping) but the power is still connected to it to maintain its position.

External Diodes. These are mentioned in the data sheet on the 5804 as possibly being necessary. However, for the hobby stepper motors we are discussing here they are not required.

Data Sheet. Download the data sheet for the UCN5804 from the Allegro website at: **allegromicro.com**

REFERENCES.

1. Control Stepper Motors with your PC, by Marque Crozman. *Silicon Chip*, january, 1994, p80.
2. Stepper Motors and how they work, by Peter Phillips. *Electronics Australia*, October & November, 1994.
3. A PC-Based Stepper-Motor Controller, by Larry Antonuk. *Popular Electronics*, June 1992, p41.
4. Computer Controlled Stepper Motors, by Jim Spence. *ETI*, august, 1994, p18.
5. Stepping Motor Driver/Interface, by Mark Stuart. *Everyday Electronics,* january, 1992, p34.
6. Linear Motion Table, by John Iovine. *Nut's 'n Volts*, august, 1995, p76.

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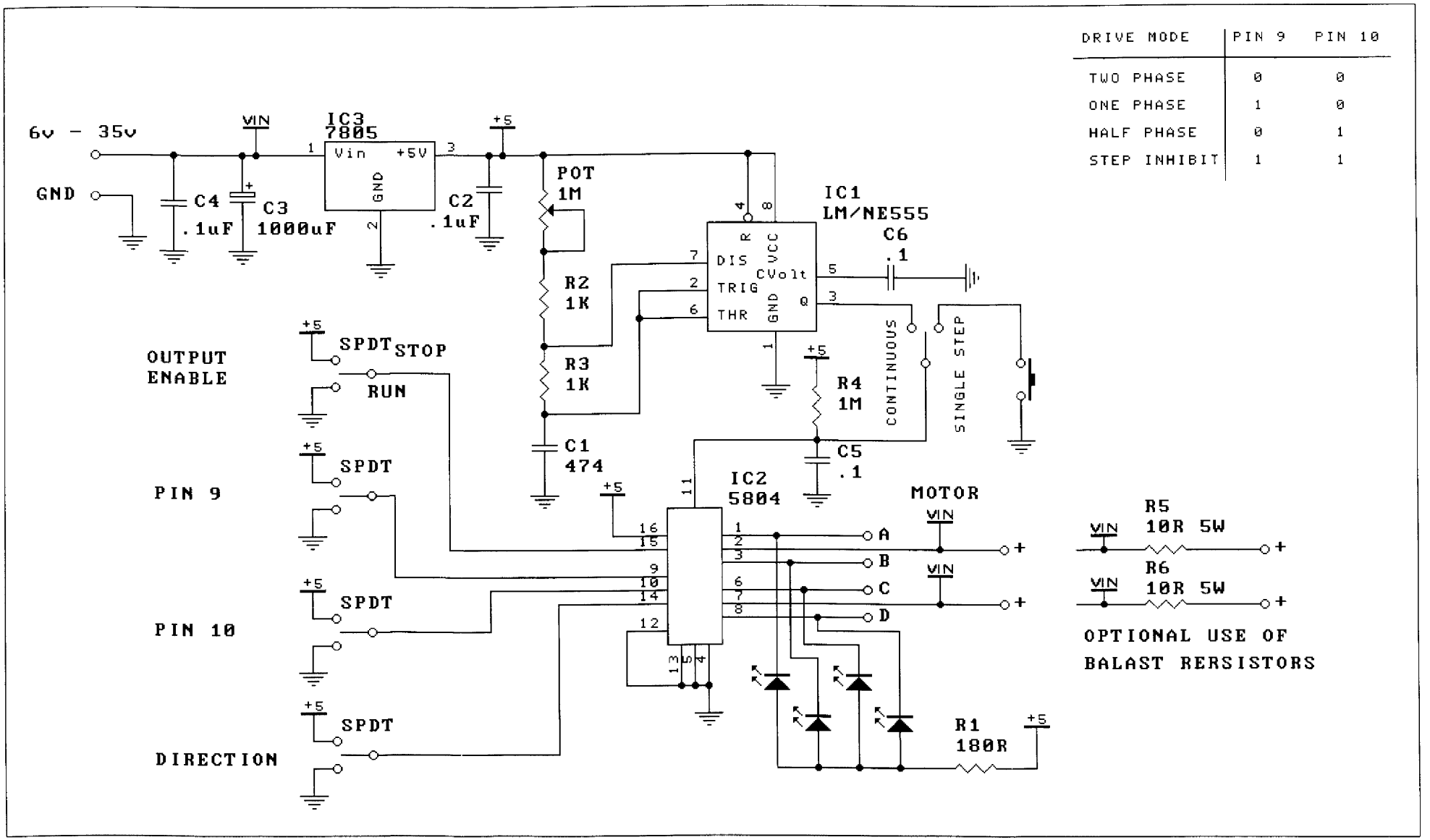

DRIVE MODE	PIN 9	PIN 10
TWO PHASE	0	0
ONE PHASE	1	0
HALF PHASE	0	1
STEP INHIBIT	1	1